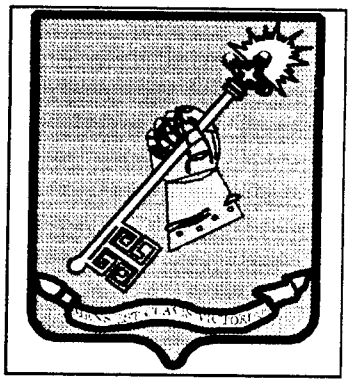
GETTING COMMAND AND CONTROL SYSTEM BACK INTO THE FIGHT ON THE DIGITIZED BATTLEFIELD

A Monograph
by

Major Lori L. S. Colodney
Signal Corps



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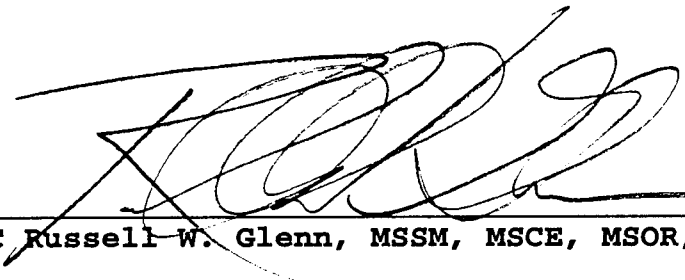

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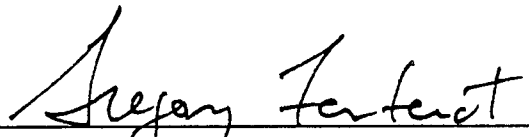

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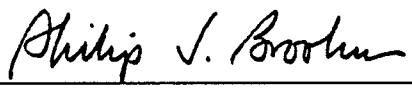

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ABSTRACT

GETTING COMMAND AND CONTROL SYSTEMS BACK INTO THE FIGHT ON THE DIGITIZED BATTLEFIELD by MAJ Lori L. S. Colodney, USA, 55 pages.

This discussion concerns C2 adequacy for land warfare in the 21st century. Doctrine, organization, and equipment for present C2 systems are based on U. S. history through World War II. However, in the ensuing fifty years technology has changed with exponential speed. The dichotomy between lack of organizational change and vast technological development forces modern leaders to question whether or not the signal corps is best serving the army's warfighters.

This analysis historically examines C2 systems to identify anachronistic thought processes. Old procedures potentially can prevent the army from fully exploiting third wave technology. With this in mind, Desert Storm and Force XXI's C2 systems are evaluated for adequacy and suitability. The criteria established to make this assessment are flexibility, reliability, agility, coverage, synchronization, and depth. The findings are that the C2 structure as planned today will not be effective on the future digitized battlefield.

The digitized battlefield requires elimination of old methodologies. A more integrated approach to the future electronics effort is advocated. The concluding remarks include recommendations for improvement to doctrine, organizational structure, and equipment. Implementation of these suggestions will produce a more effective C2 system supporting commanders on the digitized battlefield.

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Introduction

Command and control (C2) is the process of extending commanders' decisions. There are two components. The first is non-material elements such as people, organizational relationships, command arrangements, and standing operating procedures. The other is material items such as communications networks and other hardware. Together they provide a battlefield picture derived through multi-directional information paths. The best system supports commanders by rapidly communicating information with few errors. The need for a C2 system to function this way is straightforward. Commanders who are quickest to place forces at the decisive place and time on the battlefield win.

Decisiveness achieved by speed and efficiency must be a principle part of the C2 concept. This principle was recognized even in antiquity as recorded by Sun Tzu:

> "The quality of decision is like the well-timed swoop of a falcon which enables it to strike and destroy its victim. Therefore the good fighter will be terrible in his onset, and prompt in his decision."[1]

The requirement for such decisiveness makes it vital to develop a robust C2 system that swiftly provides tactical commanders maximum flexibility so forces arrive in the critical place at the correct time. As such, the C2 system's purpose is to allow commanders to see the battlefield and react faster than the enemy. The method of

capturing information to assist battlefield visualization so commanders make better decisions involves a collective process of organization, doctrine, and equipment. The desired end state has units implementing command decisions which accomplish the mission. U.S. commanders have always sought better battlefield awareness and communication to help them achieve decisiveness and victory. The Force XXI C2 concept is no different. It continues the focus on ensuring a quality C2 system for the forthcoming digitized battlefield.

As the army looks to the future, it is necessary to evaluate past C2 systems and make certain that correct lessons are derived. Equally important within the analysis is developing an evaluation criteria gleaned from both history and doctrine. Field commanders' comments during World War I, World War II, Vietnam, and the 1991 Persian Gulf War continually refer back to the following characteristics for effective C2 systems: flexibility, reliability, agility, coverage, synchronization, and depth.[2] In addition, current signal doctrinal manuals refer to these items as key characteristics within the C2 system. The following discussion uses these elements to determine if the C2 structure was effective in the past. Weaknesses where old thought processes influence future systems will be identified. Recommendations on how elimination of points where the old processes are no longer valid will be made to

strengthen the Force XXI concept. Implementation of these suggestions will strengthen the C2 system supporting the army's vision of land warfare in the 21st century.

Historical Structure of the United States C2 System

America's Civil War army organized in the Napoleonic tradition with associated staffs supporting corps and divisions. The creation of the signal corps on March 3, 1863, was based on two command desires. These needs were long range electronic signaling to assist the strategic commander and short range methods to overcome tactical limitations. Flag signaling first emerged to connect commanders with forces out of earshot. New C2 methods were also used by the Confederacy at the onset of the Civil War.

Union leadership was apprehensive about the limitations and effects on procedures associated with using new technologies. Confederate success convinced them to set aside these fears. Union officers quickly placed signalmen on the tactical battlefield. Soon semaphores were supplemented with cipher disks and field telegraphs to link commanders. The Battle of Fredricksburg is an example of how new technology and procedures linked the four union artillery divisions with assaulting troops, general headquarters, and one another to assist Union Major General Ambrose E. Burnside achieve decisive results.[3] C2 technology started supporting Union tactical decision making

by providing commanders greater battlefield awareness to synchronize combat effects.

The progression of the Union C2 system during the Civil War was not without associated growing pains. Command and staff procedures still used the previous era's methods and often inadequately exploited C2 technology. The Federals essentially fought in a well coordinated manner during the 1863 Gettysburg campaign, but a decided exception was the confusion concerning the retention of Culp's Hill by Twelfth (XII) Corps. Culp's Hill was decisive terrain for both sides. Lieutenant General Robert E. Lee wanted it taken. July 3, 1863, was the date for the rebel attack. It was up to Major General Henry W. Slocum's XII Corps to hold Culp's Hill.

There was a communications and procedural breakdown in XII Corps. Slocum and one of his division commanders, Brigadier General Alpheus S. Williams, issued conflicting orders to subordinate commanders. The lack of battlefield awareness on the part of the corps' leadership resulted in heavy losses for the 27th Indiana and 2nd Massachusetts regiments whose efforts were not coordinated. Federal soldiers paid in blood for bad timing and poor procedures.[4] Questions as to why the general officers involved did not use available messengers and telegraphy to check on vague and conflicting orders remain.

Technologies continued to mature anti-bellum and

wrought tremendous change. Electro-mechanical innovations associated with railroads, telegraphy, telephones, radios, and photography evolved and took their place in American society. These advances also found their way into military use, primarily at the strategic level. Enhanced strategic infrastructure was an unquestioned requirement. However, tactical commanders remained unconvinced as to the utility of such novel devices below division headquarters level. Infantry, cavalry, and artillery commanders questioned the usefulness of telegraphs, telephones, and radios for command and control of their maneuver forces. A modest communications organizational structure to strengthen C2 mirrored modest C2 expectations at the start of The Great War.

By WWI's end, communications networks demonstrated usefulness at improving tactical C2 and drove signal corps organizations to greater maturity. The U.S. started with two telegraph and two field battalions at the beginning of this conflict. Coordination of increasingly larger maneuver forces created demand for more reliable and flexible communications covering larger portions of the area of operations (AO). This requirement dovetailed with greater motorization of the battlefield starting in 1916.[5] In addition, U.S. commanders observed their allies' superior C2 systems and wanted similar capabilities. U.S. signal services grew in response to tactical commanders' calls for

better C2 to synchronize subordinate elements.

First World War U.S. units emulated the British by placing signal services down to battalion level.[6] Allied Expeditionary Forces had fielded 50 field signal battalions, 28 telegraph battalions, 11 signal depot battalions, and 19 service companies by the time of the armistice.[7] The standard complement for each division was a signal battalion. This unit had a headquarters and three line companies providing the division's tactical command links. It is a structure that persists today. Yet, while organizational biases started to solidify, technology continued its rapid advance.

Communications technology was a specific area where development accelerated during the interwar years. The U.S. signal corps initially assumed its C2 responsibilities were tactically oriented based upon experiences from WWI. However, the 1920 army reorganization changed the signal focus from tactical to higher levels. Signal was now reclassified as a technical service.[8] This was due in part to the unreliability of wireless communications under the rigors of combat and in part to branch parochialism. Limitations of wireless technology left commanders unconvinced as to their value to maneuver elements. This frame of mind, coupled with army downsizing, made combat arms reluctant to use personnel slots for signal soldiers. The result was a myopia that would color how the signal

corps viewed its business for years to come.

Army leadership prior to WWII decided that the signal corps was to provide command links down to division command post level. Individual branches took responsibility for C2 and its requisite communications at the tactical level.[9] The signal corps directed its energies toward providing the highest levels C2 technology. It is important to note that the Chief of Signal retained procurement responsibility for army C2 technology through the 1930s and 1940s. As such, wire-based technologies supporting larger headquarters took precedence over tactically-oriented wireless electronics development. This bias would create a shortfall of U.S. tactical communications devices well into WWII.

This was not a problem for other armies of the period. The experience in Western European conflicts between World War I and II made these armies more open to using available technologies. German commanders placed radios down to individual vehicle level at the same time the American army was de-emphasizing tactical C2 devices. Inspector of the Transport Troops, General O. Lutz and his then chief of staff, Colonel Heinz Guderian, insisted on installing mobile radios down to the tank level; an action completed by 1933.[10] These officers went to enormous effort to put effective radio systems into tanks. They recognized that improved lower level C2 helped them react more rapidly than their enemy. To this point Guderian wrote, "The continuing

development of radio apparatus is of great relevance to the direction of larger tank formations and their deployment for tasks in depth."[11] In 1940, U.S. commanders better appreciated Guderian, now a successful panzer division commander, and the tactical radios he demonstrated so effectively in battle.

Until the Germans demonstrated the power of C2 in battle, the trends in the U.S. were not on more mobile communications systems. All signal doctrine, organization, and equipment was directed at linking major headquarters together. The transition from peace to war profoundly changed how the American army viewed its C2 systems. Demand for signal units within divisions grew rapidly once the combat arms recognized the value of tactical communications. An ad hoc methodology called the cellular design was adopted.[12] A signal unit of any size was made up in response to the needs of a theater. Organizations varied in content and strength depending on location, but there were some threads of continuity as C2 doctrine adapted.

Signal embraced the ideas of flexibility, reliability, agility, coverage, synchronization, and depth as it struggled to keep up with combat troops. On July 1, 1942, the signal corps adopted a new table of organization and equipment (TOE) to provide "a flexible table...for almost any situation involving a task force."[13] Reliable new radios were bought and fielded. Tactical communications

links became key components in the synchronization process. Over time, communications concerns were integrated into the planning staff process. Evidence of this integration was found two years later when signalmen arrived with the initial landing forces on the shores of Normandy. They were necessary to facilitate the increasingly complex C2 system. C2 communications were crucial on an increasingly intricate, lethal, and dispersed battlefield.

The American army learned the value of its C2 structure on a more complex battleground. One lesson drawn from history and used in Desert Storm was the importance of communications links to the C2 process. One lesson lost was developing pliable organizational structures that responded to maneuver unit's needs. Signal organizations as late as the Gulf War continued to look as they did in 1945 despite technological changes. Signal officers still functioned on every staff in addition to placing signal units within all divisions and above organizations. It is important to assess the relevance of these doctrinal, organizational, and equipment designs. The lessons learned will assist in improving present and future C2 systems.

Adequacy of C2 Systems: Operation Desert Storm

Desert Storm Overview

Currently the army defines command and control systems as:

> . . . a process through which the activities of military forces are directed, coordinated, and controlled to accomplish the mission. This process encompasses personnel, equipment, communications, facilities, and procedures necessary to gather and analyze information, to plan for what is done, and to supervise the execution of operations.[14]

This definition addresses the complexity of the modern battlefield, but shows that the spirit of what C2 is to do remains unchanged from Civil War days. The major difference is how systems function on an increasingly fast-paced, more deadly, and more vast battlefield. The commander who effectively uses the C2 system to receive information and quickly communicate decisions will achieve victory.

Commanders judge C2 systems by how well they facilitate analysis, synthesis, and decision making. The C2 support structure must be flexible, reliable, agile, and synchronized to ensure coverage and depth. These qualities serve as tools to examine America's most recent warfighting experience. The Gulf War provides a microcosm to evaluate present American C2 systems supporting tactical commanders.

Examination of doctrine, organization, and equipment shows the army's heavy reliance upon its communications infrastructure to achieve C2. In keeping with traditional signal corps thought processes, network robustness was greatest at the strategic level. Communications links systematically diminished in number upon descent to the tactical level. It was at this most dangerous and critical

juncture where men engaged the enemy that electronic communications systems provided coverage through one means only, usually radio, or were absent. This deficiency was due to two main factors. First, the different nature of command below division level was not well understood by those providing C2 connectivity. The second weakness stemmed from historical biases influencing doctrine, organization, and equipment.

Adequacy of Doctrine

At brigade and below, commanders had adequate non-material components for their C2 system during Desert Storm. There were adequate people, organizational relationships, command arrangements, and standard operating procedures to effectively accomplish their mission.[15] It was the material component in terms of communications links that was the most serious shortfall. Doctrinal tables of organization and equipment (TOE) provided sufficient communications links for internal communications, but failed to address all external requirements.

In Desert Storm, brigade and lower command was inherently different from division and higher. These echelons did not possess all means necessary to fight as part of their organic command structure. In doctrine and practice, infantry and armor battalion headquarters and support structures were designed for employment of two to five subunits.[16] This construct provided commanders task

organizations specifically developed for their plans. However, division signal doctrine was structured to support multiples of three (for example three maneuver brigades).[17] If more units were added to the headquarters structures, then additional support was to come from higher echelon signal elements.

Higher level direct support signal units were caught in a quandary during the Gulf War. The tremendous distances and demanding requirements, such as connecting urban locations to field units, were a departure from the European scenario. Echelons above division used all of their assets and still did not meet total demands. This left no personnel or equipment to provide to lower levels. The rigid division signal battalion structure and over-reliance on higher headquarter's signal units to compensate reduced flexibility. The army alleviated doctrinally produced deficiencies by having more assets flown into the Southwest Asia (SWA) AO.

Adequacy of Organization

The American army charges its signal corps to organize itself to electronically enable effective battle command.[18] There were two historical biases which caused the signal corps problems from effectively achieving this goal during Desert Storm. The first was signal's historical concentration on supporting division headquarters and above. Tactical commanders had to force signal planners to think

outside the boundaries caused by this bias. Innovative thinking was required to get a structure that fit the combat plan. The second bias was the Cold War focus which drove unit organization to emulate the successful WWII structure. The reality of combat forced people to think and organize in new ways to make SWA communications sufficiently flexible, agile, and reliable to cover the depth of the battlefield.

The army eventually achieved redundant and reliable communications coverage from the National Command Authority (NCA) down to division headquarters level. U.S. forces were mobilized in August. By the following November, augmentation to theater signal units provided more voice and data service than in all of Europe.[19] The result was more than sufficient communications capability for high level C2. Assets supporting operational and strategic command elements were even under-used at some locations.[20] This was not the case with tactical communications within the division until immediately prior to the ground offensive.

As discussed, combat arms emphasized flexibility for its headquarters structure. Task forces of various sizes had different numbers of subunits cross attached as the mission required. The division signal battalion remained rigidly organized. The assets given in compensation were larger and less mobile than divisional mounted equipment. Initially, the division's reliance on less mobile organizations to support its C2 structure reduced coverage

and depth.

Operations (G3) and signal planners from several divisions independently developed similar modifications to circumvent organizational limitations. For example, radio relays were put on heavy high mobility multipurpose wheeled vehicles (HMMWVs) and placed directly behind lead brigades. Divisions created communications cells consisting of satellite (SATCOM), combat net radio (CNR), and mobile subscriber equipment (MSE) links and put them at the brigade main command posts (CPs). Similar cells were found at the division CP. All CPs had point-to-point "hotlines" so that command levels could synchronize the anticipated rapidly unfolding battle.[21] For uninterrupted support, it was critical to keep communications equipment within two kilometers of front line forces. There were even plans to airlift assets if necessary.

Of all systems in these cells, satellite systems were clearly the most coveted since they far surpassed MSE for covering the depth of the battlefield. Commanders insisted that large numbers of multi-channel satellite systems get sent from higher headquarters signal units to division. This was non-doctrinal but absolutely necessary. Commanders also received more single-channel satellite assets and commercial systems such as international maritime satellite (INMARSAT) systems to provide added flexibility, agility, and redundant coverage. The final result was a flexible and

reliable system supporting tactical C2.

Historical biases led to a structure not up to supporting the fight in SWA. Planners found that they had to reorganize communications so that mechanized forces kept C2 links while moving across the desert. These initial organizational flaws were due to the forty year Cold War focus. This mentality drove development of C2 communications that supported a set piece defensive fight with distances clearly specified. The division's reliance on higher level signal units worked well in this environment. The inability of this system to work equally well in the Gulf War illustrates its inherent lack of flexibility. MSE showed itself to be a product of thought processes associated with the industrial era. The army's telephone system had to adjust to the information age.

In 1985, MSE was produced to support U.S. maneuver forces under NATO.[22] Development assumptions were based on the scenario where Warsaw Pact nations fought NATO forces in Europe. The U.S., as a major leader within the alliance, saw this possibility as most likely and most dangerous. In response to the threat, NATO developed a scripted general defense plan (GDP) which was continually practiced. GDP authors assumed friendly control of most of the battlespace. War plan assumptions included NATO's ability to pre-position C2 links and tap into the commercial telephone network. The C2 system was to be in place prior to the enemy penetrating

the forward line of troops. As forces moved, the C2 system displaced to clearly delineated areas and provided adequate coverage.[23] MSE was designed and organized to support this European fight. When this system went to the desert, divisions had to make significant adjustments. The division's AO was much larger in SWA and MSE could not cover it all. As one division signal planner observed:

> For many Signal units, the desert campaign was business as usual . . . for others, specifically divisional Signal battalions. . . . the Gulf War created a new array of operational demands forcing some to change their ways of doing business . . . doctrinal PCM communications [were] obsolete.[24]

It was evident that doctrinal organizations did not meet the communications needs within division.

Adequacy of Equipment

Communications equipment was also a limiting factor. There were initially insufficient numbers to provide adequate C2 within divisions. A second issue was the lack of tactical communications equipment mobility. Together these flaws proved significant challenges to overcome for planners in the Gulf.

Major shortfalls were due to increased numbers of communications links between maneuver and habitual support units. Combat units received external support from other combat arms, combat support (CS), and combat services support (CSS) elements. The habitual nature of this augmentation support structure is know as a "slice." Slice

assets such as engineers and logistical teams enhanced the maneuver forces' ability to operate effectively. However, while tactical commanders did not command these elements, they were expected to synchronize them.

Maneuver unit's TOE did not have sufficient assets for slice elements. At the same time, these detached teams were often parceled out without a radio because the parent unit did not have enough. This doctrinal oversight did not diminish the demand for more radios. As a result, the army exhausted its depot supplies to meet these unexpected requirements.[25] Communications-Electronics Command's (CECOM) crisis actions to procure and ship adequate numbers of tactical radios were critical to mission success.

The radio system was not the only one to have asset shortages. The Army Common User System (ACUS) was the ground forces' telephone system. It was supposed to carry the vast load for tactical C2. The system was made up of two major systems; MSE and tri-services tactical (TRI-TAC) systems. Together they were ACUS's main contribution supporting a division's close battle. Yet, division signal battalions were given only enough assets for ACUS connectivity to three division CPs, maneuver brigade headquarters, and separate brigade and battalions.[26] Telephone assets appeared only as far down as battalion headquarters level. The lowest level vehicles which had mobile subscriber radio telephones (MSRT) belonged to

battalion commanders and operations staff officers. This fielding falls short of signal corps doctrine calling for C2 linkages down to company level.[27]

Another reason for added assets was the tremendous distances in the desert. In order to fill equipment shortfalls, all three generations of ACUS communications equipment went to SWA. These systems were never envisioned to work together in a connected C2 network. The disparity between C2 linking network systems required numerous interfaces, intensive management, and innovative workarounds to achieve success.[28] Communicators intensively management this fragile, unwieldy, and ever burgeoning network to prevent service interruptions.

Communications equipment shortfalls were due to two major factors. First, it was difficult covering a much bigger AO. Second, there was a lack of understanding concerning the added requirements driven by the C2 and synchronization burden placed on division maneuver units. The result was inadequate connectivity available through doctrinal organizational assets. Without added assets flown into theater, signal units would not have had adequate agility and flexibility and could not support the tactical plans. The army ended up having to take signal assets away from other world-wide missions and bring them into the Gulf AO to overcome deficiencies.[29] This was the only way to provide an adequate C2 system within the division on what

was a swift, lethal, and greatly dispersed battlefield.

Once sufficient numbers were in theater, planners grappled with the equipment's immobility. Fighting in the desert was very different from Europe in scale and scope. Division sectors were as large as 210 by 130 miles or the equivalent of South Carolina.[30] Signal assets were simply not fast enough for the planned operational tempo. A division commander noted this as a "warstopper" and elevated the issue prior to execution of the plan.[31] Dramatic changes such as placing more non-doctrinal assets at lower levels, putting equipment on different vehicles, and airlifting signal vans produced uninterrupted C2 communications. These kinds of innovation gave tactical commanders a sufficiently agile C2 system.

Adequacy of C2 Systems: The Digitized Battlefield

Force XXI Overview

The army recognizes that there is a shift in the conduct of global business. This difference directly impacts the future battlefield. While this change is described in a variety of ways, noted futurists Alvin and Heidi Tofflers' concept of "third wave" serves as a useful model for how information processing affects the world. Third wave concepts deal with the advent of information as the new basis of power. Quick and accurate decision making information brought to bear results in more money for

companies, more advantageous positions for nations, or more destructive power for militaries. The American army's leadership uses this model to set the stage for shaping its future fighting of the "information war."[32]

The Tofflers assert that organizations wanting to achieve status as the most powerful in their field must master a more accelerated environment in which economies of scale are replaced by economies of speed. Time is now the critical resource which pressures leaders to deliver "decisions in progress" if they are to react faster than the competition. Sequential planning and execution is replaced by multi-tasking and information-sharing staffs to survive in a time-based competitive situation. Anticipating this shift, the U.S. recognizes that the armed forces must learn and adapt to provide a viable force projection capability.[33]

Doctrine is the army's chosen starting point for describing its future. It serves as the engine which drives organization and equipment. The centerpiece document is Training and Doctrine Command's (TRADOC) Pamphlet 525-5, Force XXI Operations. The future vision centers around what is termed the "digitized battlefield". Force XXI considers the army's 21st century roles and missions across a spectrum of conflict. It is the conceptual framework for leveraging technology for improved warfighting.

Force XXI deals with all levels of war. However, the focus of this analysis is the tactical level and

specifically the needs of commanders at division and below.[34] General Sullivan, Chief of Staff of the Army (CSA) when TRADOC Pamphlet 525-5 was first promulgated, explained tactical digitization:

> "In our tactical units we will use information-age technology so that we can maneuver faster and mass fires more effectively. Individual weapon systems will be more potent. The digitization of the battlefield-the electronic linking of every weapon system in the Battlespace-will allow the commander to synchronize all the elements of combat power with devastating effects."[35]

On the surface these assertions appear reasonable especially in light of the Tofflers' definition for future success. However, as one delves more deeply into supporting doctrinal texts, it is apparent that industrial age, or what the Tofflers refer to as "second wave" paradigms, are not eradicated. Second-third wave fusion, where second wave processes are tied to third wave technologies, diminishes effective use of battlefield information. Slowing information captured by third wave technologies by using old methods and procedures slows a commander's ability to place combat effects at the decisive place and time in battle. As such, these second-third wave fusion points in the C2 process must be identified and updated.

Force XXI Doctrinal Adequacy

Force XXI second-third wave fusion points become readily apparent when examining the Army Battle Command Master Plan (ABCMP), the Battlefield Architecture (BA), and

the Army Battle Command System (ABCS) Campaign Plan. There is a hardware and software systems emphasis where information exchanges over multiple voice and data links. However, common hardware and software does not necessarily imply a common picture or sufficiency for battle command. It is not enough to simply overlay control systems with a plethora of technologies on top of stove-piped C2 systems.[36] Such an approach simply uses third wave power to execute second wave processes faster.

The army is not going to realize the full potential of information warfighting technologies without identifying and eliminating uses of second wave processes. The organization risks squandering the time and money invested in digitization. The doctrinal concept of the Army Battle Command System (ABCS) is central to the digitized battlefield. It is also a concept that has many second-third wave fusion points. Specifically, the evolution of the Army Tactical Command and Control System (ATCCS) and the automation products envisioned for commanders which are subsystems of ABCS need to be revamped.

The army is trying to achieve third wave results while retaining a previous era's C2 doctrinal structure. This situation should be a red flag that some paradigms have yet to shift sufficiently. Leaders must now consider the mass effects of C2 technologies in addition to the mass effects of weaponry. The army's master planners tried to design

ATCCS for such mass C2 processing. ATCCS is to consist of the Maneuver Control System (MCS), tactical fire direction (TACFIRE) system, forward air defense command, control, and intelligence (FAADC2I), all-source analysis system (ASAS), combat service support control system (CSSCS), and the army brigade and below (AB2) systems. The line of thought is that ATCCS feeds battlefield functional area (BFA) representatives located in the division or brigade main CPs. The BFA officers receive data and make an analysis. They then feed this information to the operations staff and/or commander. This process is consistent with second wave doctrine where vertical information routes are the norm. Third wave approaches call for more horizontal information flows. However, ATCCS's evolution stays fused to the vertical second wave pattern.

The Battlefield Architecture evolves over two phased time periods covering 1994 to 1999 and 2000 to 2010. During the first phase, the division and brigade architectures depict improved automated systems moving across present tactical communications system links. Transfer of data from air to ground, from BFA to maneuver, and from weapon system to weapon system all need what is termed "IVIS[intervehicle information system]-type" connections.[37] The use of IVIS-type technologies implies a data transfer requirement by combat net radio (CNR) since that is how IVIS communicates. However, CNR is already a saturated system. If alternate

data distribution systems are not identified, it will inhibit the timeliness of information transfer.

Another factor affecting timeliness is how automated information flows on the future battlefield. Weapon systems digitize information which is then transmitted to the CPs' BFA representatives. Actual information patterns still go along vertical paths to higher level BFA officers for analysis using their stove-piped computer systems. The result is that BFA digitization just makes the present C2 system faster. In effect, ATCCS doctrine marries third wave systems to second wave methodology. It is a vertical process steeped in industrial age thought.

The second time period (from 2000 to 2010) does not break this second-third wave fusion point either. Intra-BFA digitization is pervasive, but does not sufficiently cross lateral boundaries. Once again there is a hardware and software emphasis for improvement, but the actual information flow still bubbles up to division and then down to the brigade CPs for BFA expert evaluation. Most notable is that command vehicles at brigade and below remain equipped with an mobile telephone and CNR transceiver over the 15 year span. How commanders receive access to their decision support system remains unclear because MSE and CNR do not have sufficient bandwidth to accommodate the graphical displays the army desires with any speed. Commanders' reliance on BFA representatives using voice

systems to provide information is not taking advantage of third wave technology. The army needs to automate the process's analysis and synthesis portion. The retention of BFA cells throughout the BA depiction indicates a lack of any real integration of tactical automation.

Lack of tactical automation integration brings to light the problems in developing software products for commanders. The ABCMP calls for a seamless graphical display that automatically provides the appropriate scales down to the lowest level. The doctrinally provided communications network did not meet the needs of the lower commanders during Desert Storm. As such, the BA places a critical system on a network that is not agile enough to keep up with the intended customer. This makes the ABCS unreliable for brigade and below commanders unless the signal corps makes dramatic changes to doctrine, organization, and procedures. A review of signal corps publications indicates that such changes have yet to take place. These modifications are required for ABCS to meet the challenge of creating a "network or networks" within a "system of systems."[38]

Force XXI Organizational Adequacy

Second-third wave fusion is also found in Force XXI organizations. In part, the problem stems from combat support and service support organization structures being made to fit the confines of combat arms unit structures such as platoons, companies, battalions, and brigades. It is

important to move away from slicing up conventional units. Support units should be fully integrated into the combat unit down to at least battalion level. Otherwise the "one-size-fits-all" approach to developing battle command automation will not satisfy the synchronization needs of brigade and below command.

The relationship between a division and brigade commander is similar to that found between a football coach and his quarterback. The coach has an entire staff developing plays for every contingency based upon his vision of how the team should run. These plays are called in from the sidelines. However, the quarterback goes onto the playing field and will "audibilize" changes if he sees a different look than expected. The coach will know about the changes only after seeing the play. The army is asking brigade and below maneuver commanders to be that quarterback without being fully capable of audibilizing. Tactical commanders need an organic and integrated unit communications structure to facilitate rapid battlefield C2.

Habitual relationships are insufficient to meet the tactical, technical, and procedural demands of the fast-paced information battleground. If maneuver to CS/CSS relationships remain the same, then the C2 system is not robust enough as was demonstrated by Desert Storm. The present separate-signal-unit-per-division concept ignores the current unique nature of brigade and below command.

Brigades and below should have organic communications assets integrated into their structure to achieve the modularity indicated by the Force XXI operations concept.[39] The division signal battalion's manpower and equipment should be broken down and integrated into combat units.

Command is a jealously guarded part of the army system. However, command is only necessary for bringing sufficient force to bear at the decisive time and place to achieve victory. Opportunity for signal officers to command is an issue which pales in the light of the combat commander's C2 needs on a swift, lethal, and rapidly changing third wave battlefield. Tactical commanders at all levels must not get overwhelmed by data or lose connections to their decision support systems. Only a reorganized signal support approach will achieve adequate support for the future C2 system.

As planners reorganize the network to meet new battlefield challenges, automation products riding on communications links must provide commanders real-time CS/CSS information. Information must be captured and translated to the appropriate scale/level of the commander looking at the display. Otherwise, there is a real danger of information pathology. This condition occurs when systems which are designed to produce accuracy and certainty produce such quantities of information that the opposite effect occurs.[40] ABCMP's reliance on commanders sifting through data in order to make decisions creates a time

utilization problem at the lower levels. Force XXI doctrine tends to focus on quantity rather than quality. It is incumbent on the commander to push, pull, or plug-in to get information. This is an added burden to tactical commanders who already receive data from a minimum of twelve sources during battle.[41] Commanders can quickly lose mental agility if overwhelmed with information on the move.

The blueprint for the 2010 battlefield architecture shows automated systems at the lowest levels of command in a "one-size-fits-all" approach. Distribution of radio receivers is increased so that BFA officers to will greater access to automation products. Only an over-arching system providing a usable format will increase a commander's ability to make decisions. Otherwise, if commanders and staffs are simply overloaded with more data, it can hinder flexible response to the tactical situation. Agility and reliability will only increase if CS/CSS information is in a format that does not increase the amount of data that commanders and staffs must sift through to use.

Force XXI Equipment Adequacy

The army is relying on the digitized battlefield for a more integrated approach to C2 and battle command. Smarter implementation is key to the future electronics effort. For the system to furnish shared situational awareness, provide real-time information across the spectrum of conflict, and transmit orders rapidly, it must have the right equipment at

the right places on the battlefield. It is important to look at equipment issues and determine if Force XXI can bring third wave capabilities to bear.

The ABCMP provides battlefield pictures by having every weapons system and major organization linked electronically. Various displays can be shown, from individual soldiers to corps moving across the battlefield. This network of networks is thought to furnish enhanced synchronization by being able to provide commanders with common pictures. At the tactical level, enhanced synchronization enables forces to move, coordinate direct and indirect fires, and control battle effects. A common thread within this C2 fabric is that communications equipment must support individual systems to indicate weapons positions and send this information back to command displays. Otherwise network deficiencies provide an inaccurate picture. Unreliability causes commanders to revert to first wave C2 methods such as visual, voice, and commander's intent to validate the given battlefield picture. It is unfortunate that during Desert Storm smaller unit commanders relied on these first wave techniques for much of their battlefield picture.

Force XXI's communications network as presently envisaged will not be any better than its Desert Storm predecessor. It will not achieve sufficient coverage and depth to serve reliably for two reasons. First, there is a need for more frequencies without regard to the concept that

the electro-magnetic spectrum does not expand. Second, there are availability and mobility problems with the tactical equipment providing communications links. These deficiencies are major shortfalls within the ABCMP. These problems must be addressed for sufficient C2 system support to the digitized battlefield.

When demands on the electro-magnetic spectrum increase, frequencies will head the list of scarce resources ahead of more commonly thought of needs such ass fuel and ammunition. The tactical backbone for ATCCS is the wireless connections between all entities moving within the battlespace. Problems arise when looking at providing the connectivity the army wants on the battlefield. As the BA models progress over time, proliferation of transceivers is the only real architecture change. This exacerbates a situation where frequencies are already insufficient to meet the demand.[42]

The ABCMP for mobile operations puts its emphasis on four subsystems: SATCOM, wide area networks (WANs), local area networks (LANs), and a data distribution system (DDS) with broadcast capabilities.[43] All of these systems need a frequency to transmit data. In addition, every discrete unit needs its own set of frequencies to make sure that the digitized information goes to the right data consumers. Presently the average division needs 500-600 frequencies.[44] Otherwise, managers wrestle with duplication and de-

confliction as they did in Desert Storm where there were only 603 VHF frequencies available for the theater.[45]

Force XXI shows a minimum of a 100 percent requirement increase for wireless connections. Frequency availability and management will grow as an issue. C2 communications will rapidly consume the available spectrum, especially in light of the requirement to link every system on the information battleground. Signal planners will need to intensely manage frequencies to avoid interference. This was a major undertaking during Desert Storm and will prove a greater challenge on the digitized battlefield. Yet, frequency management will be central to taking advantage of wireless communications flexibility while ensuring that the system works reliably.

Other concerns relating to provision of reliable wireless communications were the actual availability and mobility of assets. For example, SATCOM demand during Desert Storm was a problem which has future implications. There were two separate issues which limited SATCOM systems and will impact information age warfighting. The first problem was that the satellites did not have enough capacity. Second, there were not enough ground assets, especially at lower levels, and those in theater were not very mobile. Commanders and planners made circumventing these problems a high priority.

In Desert Storm there were 2000 tactical satellite

(TACSAT) systems trying to access the 98 channels available on the six-satellite constellation.[46] The constellation supporting the multi-channel systems proved inadequate to demand as well. As such, competition for access reduced this system's reliability. Lower levels often got bumped off in favor of higher headquarters' communications needs.[47] The army ended up contracting for commercial services to supplement infrastructure needs. It is important to note that flexibility would have diminished greatly if another major regional conflict (MRC) had arise. The significance to the digitized battlefield is that the army must invest in expanding future space-based systems if the ABCMP is to succeed.

SATCOM systems have problems on the ground as well. It is the most agile system covering the depth of the battlefield. Planners in Desert Storm, at the insistence of commanders, discarded doctrine to gain the flexibility and reliability that these systems provide. They pushed these assets forward and even pre-positioned them behind lead armored vehicles order to meet the concept of operations. Once forces started to move, signal vehicles were not mobile enough to maintain the battle tempo. Extraordinary efforts, including placing shelters on different mobile platforms and air delivery, were used to keep them in the fight.

SATCOM was not the only communications system with mobility and availability problems. In Desert Storm the

demand for line-of-sight communications systems exceeded capacity. A key lesson learned was that the military needs increased throughput. This exigency increases as one goes to the lowest levels of battlefield command. AM/FM radio and MSE must be more transportable and available to maneuver forces. If a commander cannot depend on these links to be there, then all of the automated systems produced are for naught. Indications are that CNR did not always work when they needed it and the MSE equipment was always keeping up at all. In the words of an armored brigade commander recounting his fight in the Gulf, "If the Army had 3d wave technology, it did not have 3d wave connectivity."[48] The reliance of that commander on visual contact and intent implies that communications links were not reliable. Reliability will not enhance without changes to signal doctrine, organization, and equipment. There are no such changes forecasted at this time.

Volume of data is another concern. CNR and MSE both transmit digitized information, but were not designed as the primary digital data system. The army's DDS was to fulfil this role. DDS is to consist of systems like the enhanced position locating reporting system (EPLRS) and the joint tactical information distribution system (JTIDS). These DDS links are depicted as continuously increasing as the BA progresses over time. However, the army is not funding DDS at this time. This will swing the connectivity burden to

CNR and MSE as it does today. These systems do not have sufficient throughput for the projected video and graphics required for future automation. In addition, there are not adequate numbers of communications systems projected for the added demand.

ABCS impacts a commander's ability to make timely battle decisions on the digitized battlefield. Reliability is dependent on the availability of the communications links. C2 equipment is not going to be up to the task of supporting the digitized battlefield using present doctrine, organization, and equipment. Alternatives and solutions must be found now in order to impact on the 2010 digitized battlefield. The network of networks cannot be as fragile, unable to handle volume, or as immobile as projected in the BA.

Recommendations and Conclusions

Recommendation Overview

Historical, Desert Storm, and Force XXI analysis suggests that future battlefields will continue to be faster, less dense, and more lethal. C2 systems will have to exploit the third wave environment if U.S. ground forces are to achieve success. As presently configured and projected out to 2010, the C2 system does not meet the needs of the digitized battlefield. However, there are inexpensive solutions that make immediate improvements which

can serve as adequate stop gap measures. There are also some longer term questions that must be addressed. The most important issue is determining second-third wave fusion points. Once identified, C2 architects must break old thought patterns so that the army uses third wave technology to its fullest potential.

Recommended Doctrinal Changes

Army doctrine needs to re-address how brigades and below are supported. Force XXI does not challenge the assumption that it is correct to have the division be the lowest unit level with all organic assets for necessary for independent deployment. Such an assumption is a second-third wave fusion point. This premise may be true for high intensity conflict scenarios, but it ignores the larger trend toward operations other than war (OOTW). OOTW missions are an increasing demand on the army's resources. These kinds of missions rarely require a division's full combat force. It is far more common to have division plan the mission, organize an ad hoc task force structure, and then monitor the situation.

TRADOC Pamphlet 525-5 describes the need to build a modular capability in which an appropriately sized force can be quickly projected into an AO. The army can ill afford to retain a doctrine which has brigades deploying without robust organic CS/CSS elements. It is not time effective to have to reinvent the brigade structure and give it a

deployment slice directly before departure. Given the complexity of the Force XXI environment, army doctrine must provide for brigades with an integrated structure. The modular brigade approach would give all assets needed to conduct independent action as part of the maneuver TOE. In this way, the brigade trains as a team, has more integrated CS/CSS planning for its operations, and is more rapidly deployable.

An example of how CS can be fully integrated into maneuver units is with the division signal assets. The signal community must use third wave thinking to support the digitized battlefield C2 system. A thorough analysis of digitized fighting along the entire spectrum of conflict must be considered. The signal corps must realign its doctrine by shattering existing thoughts about organization and structure to provide sufficient connectivity for the future C2 system.

One of the first acts the signal corps should take is to eliminate the dual staff and unit structure (which is a throwback from WWII). There is still a staff signal officer with a small detachment at all levels down to battalion. In addition, there are signal units at every echelon from division level and higher.[49] This concept reflects the large headquarters support bias of the signal community and is unnecessarily redundant.

A more efficient approach is to place a staff and a

command hat on all signal officers in the army's structure. This concept already is in place for division signal battalion and corps signal brigade commanders. These individuals command a unit and are also special staff officers to division and corps commanders respectively. In order to dual hat all signal officers, the division signal battalion should be broken up and integrated into combat units. All signal officers would then command their signal assets and be special staff officers to their maneuver commander. This doctrinal change would provide a more synchronized planning effort for operations.

MSE doctrine calls for division signal battalions to relinquish control of assets to corps units or above upon deployment.[50] Division's network control systems are in place for purposes of redundancy. The result is that division signal officers monitor the network and respond to crises. A more effective role would be this dual hat concept so that every signal officer is used throughout operations. One example is that the signal battalion operations officer (S3) could also be the assistant division signal officer (ADSO). Additionally, signal unit commanders and platoon leaders also become maneuver brigade and battalion signal officers. In effect, the division signal officer commands a virtual battalion whose talents are fully used by the division.

The above-described doctrinal changes would better

serve commanders and maneuver units. It would drive placement of expertise and equipment in to combat units so that communications connectivity can be practiced and perfected for future high tempo battlefields. Signal officers assigned would then have a vested interest in support to that maneuver organization, but also have an appreciation for their part in the overall C2 network. This approach also places signal assets forward in greater depth so that they are quicker to get in and cover the fight.

Recommended Organizational Changes

Force XXI must be more integrated at lower levels to make independent fighting packages available for immediate deployment. This is true for combat arms, CS, and CSS alike. Independent teams give the army tremendous flexibility and agility on the battlefield. These teams do not take away the commander's ability to cross attach or weight an effort, but rather reduces the need to do so as often. As such, the standing task forces are more synchronized since they train together. In order to illustrate this point, the signal corps example again will be used.

Suggested changes to doctrine require organizational changes within the signal battalion. The battalion as a separate entity ceases to exist as the assets are integrated into the maneuver units. All signal officers are dual hatted as staff and line officers. They still plan and

execute the C2 support network, but control and monitor a "virtual battalion". This concept is not as far a departure from the conventional concepts of support as one may think. Basic signal doctrine specifies:

> Armored, infantry, and mechanized battalions fight the battle and are the combat edge of the division. Our communications system is based on the needs of these battalion.[51]

A separate signal battalion served the needs of the division in the Cold War. The virtual signal battalion will be more effective on the future digitized battlefield.

The equipment that goes with the virtual signal unit must also be reorganized so that the supported maneuver unit can communicate independently. Battalions and brigades must be able to provide for hierarchial, lateral, and slice connections as appropriate. This will require more people and equipment given to lower levels. Lower level signal support is key for providing commanders flexible, reliable, and agile C2 systems which assist decision making and communicating those decisions faster.

Recommended Equipment Changes

Technology will continue to change the battlefield C2 system. There are already efforts, such as spread spectrum technology, reduced bandwidth systems, and packet switching, that have eased difficulties.[52] There are two additional ways C2 equipment systems can change to better support the digitized battlefield. First, using commercially available technology innovatively can improve commanders' ability to

get information and communicate decisions. The second approach is to make present systems more mobile.

An existing and inexpensive third wave technology that is already in great proliferation which can provide ground forces great benefit is paging. Commercial paging provides two ways to shatter second-third wave fusion regarding frequency management and data distribution. Today's signal planners assign units a number of different frequencies to avoid information flowing to incorrect users. A concept similar to the way commercial paging is done can eliminate this second wave paradigm. The theory behind paging uses a single frequency to provide literally thousands of customers information. The signal broadcasts a single piece of data to the entire AO. Within this signal is an unique device address. The device or group of devices addressed respond by displaying the information. No other users get this message even though their receivers are on the same frequency. If the C2 community used similar smart devices for the data distribution system, then many frequency requirements can be eliminated. It also eliminates the need for centralized frequency management.

The other way to use paging on the battlefield to allow commanders another capability to audibilize. It is not difficult to placing paging transceivers in all vehicles with radios. In addition, the leadership can be assigned a personal pager. Commanders can send 120 to 180 character

alphanumeric messages very quickly. In this way, they can rapidly advise subordinates and higher of changes. This system does not even require encryption. The reason for this is twofold. Primarily, the message volume makes it impossible for an enemy to track who is getting instructions. Every message is broadcast by every node so there is no signature letting the enemy analyze patterns or volume changes. In addition, The enemy will not be privy to the list denoting which numbers correspond to which individual pager. The other reason is that paging messages will be so time sensitive that, even if the enemy were to figure out a trend, it would too late to react. Paging as a concept and a practical system is but one example of a way to capitalize on third wave technology inexpensively.

Finally, it does not matter how good paging or any other third wave technology is if it does not keep up with maneuver forces. Communications must be made more mobile. Other support branches such as the military intelligence and chemical corps have been more savvy regarding this need for greater mobility and place some assets on tracks.[53] The army is currently retiring many M113 family of vehicles (FOV). These chassis would be made available for the signal community cheaply.[54] It is true that these vehicles are slower than Abrams tanks and Bradley fighting vehicles; however, they will still significantly increase mobility over the present vehicle configurations.

Conclusion

The army's C2 organization is based on a second wave environment. Technology has changed with exponential speed over the past fifty years. The dichotomy between lack of organizational change and vast technological development forces modern leaders to question whether or not the present C2 systems and their connectivity are best serving the army's tactical warfighters. Evaluating the C2 system in terms of flexibility, reliability, agility, coverage, synchronization, and depth shows that is was not adequate during Desert Storm.

Assessing the Gulf War experience along with an analysis of Force XXI doctrine leads to the conclusion that the present design of the C2 structure for a truly third wave information war is not adequate. The proposed doctrine, organization, and equipment is flawed by second wave thought processes. Articulated within this analysis are ways to shatter these second-third wave fusion points. The recommended changes will help improve the ABCMP, BA, and other supporting doctrinal documents. The conclusions drawn provide the army with a road map for creating an adequate C2 system to fight the information war.

Appendix A: Glossary

ABCMP	Army Battle Command Master Plan
AB2	Army Brigade and Below System
ABCS	Army Battle Command System
ACUS	Army Common User System
ADSO	assistant division signal officer
AO	area of operation
ASAS	all-source analysis system
ATCCS	Army Tactical Command and Control System
BA	battlefield architecture
BFA	battlefield functional area
CECOM	Communications-Electronics Command
CNR	combat net radio
C2	command and control
CP	command post
CS	combat support
CSA	Chief of Staff of the Army
CSS	combat service support
CSSCS	combat service support control system
DDS	data distribution system
EPLRS	enhanced position locating reporting system
FAADC2I	forward air defense command, control, and intelligence
GDP	General Defense Plan
HMMWV	heavy high mobility multi-purpose vehicle
IVIS	intervehicle information system
JTIDS	joint tactical information distribution system
LAN	local area network
MCS	maneuver control system
MRC	major regional conflict
MSE	mobile subscriber equipment
MSRT	mobile subscriber radio telephone
OOTW	operations other than war
SATCOM	satellite communications systems
SWA	Southwest Asia
TACFIRE	tactical fire direction system
TACSAT	tactical satellite system
TOE	table of organization and equipment
TRADOC	Training and Doctrine Command
TRI-TAC	tri-services tactical communications system
WAN	wide area network

Endnotes

1. Thomas R. Phillips, Roots of Strategy, vol. 1, The Art of War, by Sun Tzu, trans Lionel Giles (Harrisburg, PA: Stackpole Books, 1985), 31-32.

2. U. S. Department of the Army, Field Manual 24-1 Signal Support in the Airland Battle, (Washington, D. C.: Government Printing Office, October 1990), 2-1. The use of flexibility, reliability, agility, coverage, synchronization, and depth as the criteria for evaluation of adequacy is derived from both history and present signal corps doctrine. The comments of field commanders during World War I, World War II, Vietnam, and the 1991 Persian Gulf War continually refer back to some or all of these characteristics for effective command and control systems. In addition, all current field and technical manuals refer to these items as the most important criteria. Yet it is important to note that signal doctrine defines optimal signal in FM 24-1 on page 2-5 as "support which allows the commander to locate wherever he desires." This is a recognition of the combined effect of the above characteristics which allows commanders to be wherever needed in order to make decisions and win.

3. Edward Hagerman, The American Civil War and the Origins of Modern Warfare (Indianapolis: Indiana University Press, 1988), 79.

4. Edwin B. Coddington, The Gettysburg Campaign: A Study of Command (New York: Charles Scribner's Sons, 1984), 474-475.

5. Kenneth Macksey, For Want of a Nail, (London: Brassey's, 1990), 79.

6. R. E. Priestley, The Signal Service in the European War of 1914 to 1918 (France), (Chatham: W. & J. Mackay & Co., LTD., 1921), 14.

7. Dulany Terrett, The United States Army in World War II, The Technical Services, The Signal Corps: The Emergency (To December 1941), (Washington, D. C.: Government Printing Office, 1956), 21.

8. Terrett, The Emergency, 23.

9. Terrett, The Emergency, 23.

10. David Woods, A History of Tactical Communications Techniques, (New York: Arno Press, 1974), 200.

11. Heinz Guderian, Achtung-Panzer, (New York: Arms and Armour Press, 1937), 138.

12. George R. Thompson and Dixie R Harris, United States Army in World War II, The Technical Services, The Signal Corps: The

Outcome (Mid-1943 Through 1945), (Washington, DC: U. S. Government Printing Office, 1966), 23.

13. Thompson and Harris, Outcome, 23-24.

14. U. S. Department of the Army, Field Manual 101-5-1 Operational Terms and Symbols, (Washington, D. C.: Government Printing Office, October 1985), 1-16.

15. Robert H. Scales, Certain Victory: The US Army in the Gulf War, (Leavenworth, KS: Selected Reprint, US Army Command and General Staff College Press, 1994), 106-108.

16. U. S. Department of the Army, Field Manual 71-3: Armored and Mechanized Infantry Brigade, (Washington, D. C.: Government Printing Office, 11 May 1988), 1-5.

17. U. S. Department of the Army, Field Manual 11-50 Combat Communications within the Division (Heavy and Light), (Washington, D. C.: Government Printing Office, 4 April 1991), 2-5.

18. U. S. Department of the Army, Field Manual 100-5 Operations, (Washington, D. C.: Government Printing Office, June 1993), 2-24.

19. George T. Raach, ed., Title V Final Report to Congress on the Conduct of the Persian Gulf War, (Washington, D. C.: United States Department of Defense, 1992), 561.

20. Center for Lessons Learned On-line Database. Two entries from Center for Lessons learned during the Gulf War, "MSE Not Utilized Fully" and "Utilization of the EAC Small Extension Node (SEN)", refer to capability not used to capacity especially at corps and echelons above corps (EAC) levels.

21. This is a synthesis from multiple sources. Most notable references are the from Center for Army Lessons Learned (CALL) On-line Database, the communications plan in the 24th Mechanized Infantry Division Combat Team Historical Reference Book, April 1991, and from Randolph W. House and Gregory Johnson, "C2 In A Heavy Brigade," Campen, Alan D. ed., The First Information War: The Story of Communications, Computers, and Intelligence Systems in the Persian Gulf War, Fairfax, Va: AFCEA International Press, 1992, 101-107.

22. Richard Davis, "Battlefield Automation, Army Command and Control Systems Acquisition Cost and Schedule Changes," Fact

Sheet for the Chairman, Subcommittee on Defense, Committee on Appropriations, House of Representatives, (Washington, DC: General Accounting Office, December 9, 1987), 19.

23. Paul H. Herbert, Deciding What Has To Be Done: General William E. Depuy and the 1976 Edition of FM 100-5, Operations, Leavenworth Papers, no. 16, (Ft. Leavenworth, KS: Combat Studies Institute, June 1988), 102.

24. Wayne White, "Communicating On the Move," Campen, Alan D. ed., The First Information War: The Story of Communications, Computers, and Intelligence Systems in the Persian Gulf War, (Fairfax, Va: AFCEA International Press, 1992), 93.

25. Richard Bingham, CECOM and the War For Kuwait: August 1990 - March 1991, (Ft. Monmouth, NJ: U. S. Army Communications-Electronics Command, May 1994), 25. A good example of this demand is the hand held radios and small unit transceivers. CECOM shipped all 9,000 it had in depot and still had an added 1,000 requested by ARCENT which required the purchasing of a commercial equivalent.

26. U. S. Department of the Army, Field Manual 11-30 MSE Communications in the Corps/Division, (Washington, D. C.: Government Printing Office, 27 February 1991), 2-9.

27. U. S. Department of the Army, Field Manual 24-1 Signal Support in the Airland Battle, (Washington, D. C.: Government Printing Office, October 1990), 1-6.

28. George T. Raach, ed., Title V Final Report to Congress on the Conduct of the Persian Gulf War, (Washington, D. C.: United States Department of Defense, 1992), 566.

29. Raach, Title V, 567-568. EUCOM deployed all forms of communications assemblages/equipment and personnel to augment the communications in place. In addition, three of the four EAC battalions were deployed into SWA AOR. This was at the expense of the EUCOM mission which was deemed as waning in light of the diminished Warsaw Pact threat.

30. Scales, Certain Victory, 90.

31. 24th Mechanized Infantry Division Combat Team Historical Reference Book, (Ft. Stewart, GA: United States Department of the Army, 1991), xxx.

32. TRADOC Pamphlet 525-5 Force XXI Operations, (Ft. Monroe, VA: Training and Doctrine Command, 1 August 1994), 1-5.

33. Alvin and Heidi Toffler, War and Anti-War, (New York: Little, Brown, and Company, 1993), 63.

34. CSA Message: Building the Force for the 21st Century, Force XXI, 081145z Mar 94, 2. This army-wide notice directed that the focus of the effort to digitize the army will be the division. Units subordinate and echelons above would derive Force XXI operational doctrine from the lessons learned at the division level.

35. Gordon R. Sullivan, "America's Army-Focusing on the Future," Army: The Green Book 1994-5, vol. 44, no. 10, October 1994, 23.

36. The common literature defines stove-piped as vertically moved/integrated information or data.

37. Battlefield Architectures 1994-1999-2010 (Brigade-Corps) Architecture Annex to Section IV, IBTA Handbook, (Ft. Leavenworth, KS: Combined Arms Command, 1 May 1994), 1999 Division Architecture.

38. Army Battle Command Master Plan 1994, (Ft. Monroe, VA: Training and Doctrine Command, 19 Sep 94), 4-16.

39. TRADOC Pamphlet 525-5, 3-2.

40. Martin Van Creveld, Command in War, (Cambridge, MA: Harvard University Press, 1985), 259.

41. U. S. Department of the Army, Field Manual 11-32 Combat Net Radio Operations, (Washington, D. C.: Government Printing Office, 15 October 1990), 1-6. The individuals/representatives consistently depicted talking on the command net are as follows: three subordinate commanders, S2, S3, artillery, engineers, aviation, ADA, signal, ALO, and logistics.

42. Center for Lessons Learned. There are multiple entries on how the equipment could not keep up with maneuver forces during the envelopment. One example is an entry entitled, "Extended Range Communications for Maneuver Units," where it was observed that, "Maneuver units quickly outdistanced the tactical switching networks ability to keep up with lead unit." Many vignettes also are published to this effect. One example is from the Maggart and Fontenot article where it was recounted on page 32, "In TF 2/34, the task force commander's radios quit when 12 or more rounds of Iraqi artillery impacted on his chosen vantage point, so he moved northeast at a high rate of speed in order to get back in the fight and, hopefully, back in communication." Examples like these explicitly show that communications equipment

did not prove agile enough to cover the entire battlespace.

43. ABCMP 1994, 4-16.

44. SFC William C. Prate, Frequency Management Noncommissioned Officer, 1st Infantry Division, telephone interview by author, 21 November 1994.

45. Donald L. Jones and Richard C. Randt, "The Joint CEOI," in Campen, Alan D. ed., The First Information War: The Story of Communications, Computers, and Intelligence Systems in the Persian Gulf War, (Fairfax, Va: AFCEA International Press, 1992), 161-166. The NSA worked through this problem by reusing frequencies. More than a dozen editions were published and they consisted of more than a half-million pages and weighed over 85 tons.

46. Allen D. Campen, "Silent Space Warriors," in Campen, Alan D. ed., The First Information War: The Story of Communications, Computers, and Intelligence Systems in the Persian Gulf War, (Fairfax, Va: AFCEA International Press, 1992), 138.

47. 24th Mechanized Infantry Division Combat Team Historical Reference Book, (Ft. Stewart, GA: United States Department of the Army, 1991), Memo by MG Barry McCaffrey, 24ID Commander to COL (P) Ayers dtd 20 Nov 90. This memorandum states the concerns of subordinate commanders getting bumped off the satellite systems. MG McCaffrey wrote, "Frank, We must have Div level TAC SAT multi-channel PCM to make [Desert Storm] concept work. Cannot allow VII Corps satellite requirements to knock Div level systems off the bird."

48. Lon E. Maggart and Gregory Fontenot, "Breaching Operations: Implications for Battle Command and Battle Space, Military Review, February 1994, 34.

49. U. S. Department of the Army, Field Manual 24-1 Signal Support in the Airland Battle (Washington, D. C.: Government Printing Office, October 1990), 2-10.

50. U. S. Department of the Army, Field Manual 11-30 MSE Communications in the Corps/Division, (Washington, D. C.: Government Printing Office, 27 February 1991), 4-26.

51. U. S. Department of the Army, Field Manual 11-50 Combat Communications within the Division (Heavy and Light), (Washington, D. C.: Government Printing Office, 4 April 1991), 7-1.

52. Major Rodney B. Roeber, S3, 121st Signal Battalion, 1st Infantry Division, telephone interview by author, 10 November 1994.

53. U. S. Department of the Army, Field Manual 34-8 Combat Commander's Handbook on Intelligence, (Washington, D. C.: Government Printing Office, 28 September 1992, appendix B. This manual shows systems on both M105 and M113 chassis.

54. Scott R. Gourley, "A Workhorse Gets New Power." Army 44, no. 7, (July 1994), 42. "Some systems are being retired (M125, M741 and M1015 series). Other derivatives are being displaced because of army downsizing or replacement with other systems (M548, M730, M901, M981, M106 and M577 series)."

BIBLIOGRAPHY:

Books

Campen, Alan D. ed. The First Information War: The Story of Communications, Computers, and Intelligence Systems in the Persian Gulf War. Fairfax, Va: AFCEA International Press, 1992.

Coddington, Edwin. The Gettysburg Campaign: A Study of Command. New York: Charles Scribner's Sons, 1984.

C3I Handbook, Edition Three. Paolo Alto: Defense Electronics, 1988.

Cushman, John H. Command and Control of Theater Forces: Adequacy. Washington, D. C.: AFCEA International Press, 1991.

Cushman, John H. Command and Control of Theater Forces: The Korea Command and Other Cases. Cambridge: Harvard University Program on Information Resources Policy, 1986.

Guderian, Heinz. Achtung-Panzer! New York: Sterling Publishing, 1937.

Hagerman, Edward. The American Civil War and the Origins of Modern Warfare. Indianapolis: Indiana University Press, 1988.

Macksey, Kenneth. For Want of a Nail. London: Brassey's, 1990.

Macksey, Kenneth. Technology in War. New York: Prentice Hall Press, 1986.

Phillips, Thomas R. Roots of Strategy. Vol. 1, The Art of War, by Sun Tzu, trans Lionel Giles. Harrisburg, PA: Stackpole Books, 1985.

Priestley, R. E. The Signal Service in the European War of 1914 to 1918 (France). Chatham: W. & J. Mackay & Co., LTD., 1921.

Rackham, Peter, ed. Jane's C3I Systems 1991 - 1992. London: Butler and Tanner LTD., 1991.

Scales, Robert H. Certain Victory: The U. S. Army in the Gulf War. Leavenworth, KS: Selected Reprint, U. S. Army Command and General Staff College Press, 1994.

Terrett, Dulany. The United States Army in World War II, The Technical Services, The Signal Corps: The Emergency (To December 1941). Washingon, D. C.: Government Printing Office, 1956.

Thompson, George R. and Dixie R. Harris. The United States Army in World War II, The Technical Services, The Signal Corps: The Test. Washingon, D. C.: Government Printing Office, 1954.

Thompson, George R. and Dixie R. Harris. United States Army in World War II, The Technical Services, The Signal Corps: The Outcome (Mid-1943 Through 1945). Washington, D. C.: U. S. Government Printing Office, 1966.

Toffler, Alvin and Heidi. War and Anti-War. New York: Little, Brown, and Company, 1993.

Van Creveld, Martin. Command in War. Cambridge: Harvard University Press, 1985.

Van Creveld, Martin. Supplying War. Cambridge: Cambridge University Press, 1977.

Williamson, John, ed. Jane's Military Communications 1991 - 1992. London: Butler and Tanner LTD, December 1991.

Woods, David. A History of Tactical Communications Techniques. New York: Arno Press, 1974

Manuals

U. S. Department of the Army. Field Circular 71-6 Battalion and Brigade Command and Control. Washington, D. C.: Government Printing Office.

U. S. Department of the Army. Field Manual 11-30 MSE Communications in the Corps/Division. Washington, D. C.: Government Printing Office, 27 February 1991.

U. S. Department of the Army. Field Manual 11-32 Combat Net Radio Operations. Washington, D. C.: Government Printing Office, 15 October 1990.

U. S. Department of the Army. Field Manual 11-37 MSE Primer for Small-Unit Leaders. Washington, D. C.: Government Printing Office, 14 November 1990.

U. S. Department of the Army. Field Manual 11-38 MSE System Management and Control. Washington, D. C.:

Government Printing Office, 4 April 1991.

U. S. Department of the Army. Field Manual 11-41 Signal Support: Echelons Corps and Below (ECB). Washington, D. C.: Government Printing Office, 18 December 1991.

U. S. Department of the Army. Field Manual 11-45 Signal Support: Echelons Above Corps. Washington, D. C.: Government Printing Office, September 1992.

U. S. Department of the Army. Field Manual 11-50 Combat Communications within the Division (Heavy and Light). Washington, D. C.: Government Printing Office, 4 April 1991.

U. S. Department of the Army. Field Manual 24-1 Signal Support in the Airland Battle. Washington, D. C.: Government Printing Office, October 1990.

U. S. Department of the Army. Field Manual 24-12 Communications in a "Come-As-You-Are" War. Washington, D. C.: Government Printing Office, 17 July 1990.

U. S. Department of the Army. Field Manual 24-24 Communications-Electronics Management System. Washington, D. C.: Government Printing Office, 30 June 1977.

U. S. Department of the Army. Field Manual 24-35 Signal Operating Instructions: The "SOI". Washington, D. C.: Government Printing Office, 26 October 1990.

U. S. Department of the Army. Training Circular 24-24 Signal Data References: Communications-Electronics Equipment. Washington, D. C.: Government Printing Office, 3 October 1988.

U. S. Department of the Army. Field Manual 71-3: Armored and Mechanized Infantry Brigade. Washington, D. C.: Government Printing Office, 11 May 1988.

U. S. War Department. Field Service Regulations FM 100-5 Operations. Washington, D. C.: Government Printing Office, 1941.

U. S. Department of the Army. Field Manual 101-5-1 Operational Terms and Symbols. Washington, D. C.: Government Printing Office, October 1985.

Articles and Pamphlets

Ackerman, Robert K., "Bytes Transform Army, Turn Service Roles Upside Down," Signal, vol 48, no. 9, (May 1994): 21-20.

Albano do Amarante, Jose C.,"The Automated Battle: A Feasible Dream?," Military Review, vol LXXIV, no. 5, (May 1994): 58-61.

C4I for the Warrior, Washington, D. C.: Government Printing Office, June 12, 1993.

Clark, Wesley K., ed., "Digital Information Nodes Establish Force Dominance," Signal, vol. 48, no. 9, (May 1994): 45-48.

Clark, Wesley K., ed., "Digitization: Key to Landpower Dominance," Signal, vol. 48, no. 9, (May 1994): 27-34.

Franks, Fredrick M. Jr., Battle Labs, Fort Monroe: Training and Doctrine Command Publication, 1994.

Gourley, Scott R., "A Workhorse Gets New Power." Army 44, no. 7, (July 1994): 41-44.

Herbert, Paul. Deciding What Has To Be Done: General William E. Depuy and the 1976 Edition of FM 100-5, Operations. Leavenworth Papers, no. 16, June 1988.

Maggart, Lon E. and Gregory Fontenot., "Breaching Operations: Implications for Battle Command and Battle Space," Military Review, (February 1994): 19-35.

Robinson, Clarence H., "Army Views Combat Future In Digitalized Battlefield Tempo," Signal, vol 48, no. 9, (May 1994): 27-34.

Roos, John G.,"InfoTech InfoPower," Armed Forces Journal International, (June 1994): 31-36.

Sass, Paul and Ingrid Eldridge, "Army Demonstrates Wideband On-the-Move Communications for Digitized Battlefields," Signal, vol 48, no. 7 (March 1994): 54-55.

Sullivan, Gordon R., and James M. Dubik, "Land Warfare in the 21st Century," Military Review, (September 1993): 13-32.

Sullivan, Gordon R., "America's Army-Focusing on the

Future," Army: The Green Book 1994-5, vol. 44, no. 10 (October 1994): 19-29.

Unpublished Dissertations, Interviews, Papers, and Reports

A History of the 24th Mechanized Infantry Division Combat Team During Operation Desert Storm. Ft. Stewart, GA: United States Department of the Army, 1991.

Army Battle Command Master Plan 1994. Ft. Monroe, VA: Training and Doctrine Command, 19 Sep 94.

Battlefield Architectures 1994-1999-2010 (Brigade-Corps). Ft. Leavenworth, KS: Combined Arms Command, 1 May 1994.

Bingham, Richard. CECOM and the War For Kuwait: August 1990 - March 1991. Ft. Monmouth, NJ: U. S. Army Communications-Electronics Command, May 1994.

Blank, Stephan J. The Soviet Military Views Operation Desert Storm: A Preliminary Assessment. Carlisle: Strategic Studies Institute U. S. Army War College, 23 September 1991.

Brown, Armor D. Reviewing Command and Control for a Heavy Brigade: Tweaking the Design of Forward Command Posts. Leavenworth: School of Advanced Military Studies, 1992.

CSA Message: Building the Force for the 21st Century, Force XXI. 081145z Mar 94.

Davis, Richard. "Battlefield Automation. Army Command and Control Systems Acquisition Cost and Schedule Changes," Fact Sheet for the Chairman, Subcommittee on Defense, Committee on Appropriations, House of Representatives. Washington, D. C.: General Accounting Office, December 9, 1987.

Hesser, Andrew and Roger B. Grind. Force Level Control System Experiment #2: Brigade TOC Information Flows, Including Commander's Critical Information Requirements and the Effect of Automation on Command and Control. Richland, Washington: Pacific Northwest Laboratory, May 1990.

Joint Tactical Command, Control, and Communications Agency Desert Shield Desert Storm Lessons Learned Report. Ft. Huachucha: Joint Interoperability Test Center, March 1991.

MAJ Rodney B. Roeber. S3, 121st Signal Battalion, 1st Infantry Division. Telephone interview by author, 10 November 1994.

McKiernan, David D. Command, Control, and Communications at the VII Corps Tactical Command Post: Operation Desert Shield/Desert Storm. Carlisle: Army War College, 1992.

93d Signal Brigade After Action Report Desert Shield Desert Storm, 11 March 1991.

93d Signal Brigade After Action Briefing Desert Shield Desert Storm, 11 March 1991.

93d Signal Command Report Desert Shield Desert Storm, March 1991.

Raach, George T., ed. Title V Final Report to Congress on the Conduct of the Persian Gulf War. Washington, D. C.: United States Department of Defense, 1992.

Romjue, John L. TRADOC Suport to Operation Desert Shield and Desert Storm: A Preliminary Study. Ft. Monroe, VA: United States Training and Doctrine Command, 1992.

Sessions, Sterling D. and Carl R. Jones. "Interoperability: A Desert Storm Case Study," McNair Paper Eighteen. Washington, D. C.: National Defense University, August 4, 1993.

Smith, Marcia S. "Military and Civilian Satellites in Support of Allied Forces in the Persian Gulf War," Congressional Research Service Report for Congress. Washington, D. C.: Library of Congress, February 27, 1991.

SFC William C. Prate. Frequency Management Noncommissioned Officer, 1st Infantry Division, telephone interview by author, 21 November 1994.

TRADOC Pamphlet 525-5 Force XXI Operations. Ft. Monroe, VA: Training and Doctrine Command, 1 August 1994.

24th Mechanized Infantry Division Combat Team Historical Reference Book. Ft. Stewart, GA: United States Department of the Army, 1991.